

## LINEAR OPTICAL SAMPLING METHOD AND APPARATUS

### Abstract

A linear optical sampling apparatus, temporally samples a modulated optical signal using the amplitude of the interference of its electric field with the electric field of a laser pulse. The apparatus includes a 90° optical hybrid that combines the optical signal and laser pulse in order to generate two quadratures interference samples  $S_A$  and  $S_B$ . A processor compensates for optical and electrical signal handling imperfections in the hybrid, balanced detectors, and A/D converters used in the optical sampling apparatus. The processor numerically scales the two quadratures interference samples  $S_A$  and  $S_B$  over a large collection of samples by imposing that the average  $\langle S_A \rangle = \langle S_B \rangle = 0$  and  $\langle S_A^2 \rangle = \langle S_B^2 \rangle$  and then minimizes  $2 \langle S_A \cdot S_B \rangle / (\langle S_A^2 \rangle + \langle S_B^2 \rangle)$   $= \cos(\varphi_B - \varphi_A)$ . This is done by adjusting the phase between the two quadratures (ideally either  $-\pi/2$  or  $+\pi/2$ ) so that  $\cos(\varphi_B - \varphi_A)$  is zero. The processor then generates a demodulated sample signal using the quadratures interference samples  $S_A$  and  $S_B$ . According to one feature, the hybrid sets the relative phase between two quadratures of their interferometric component so that the phase sensitivity inherent to linear optics is removed. A variety of hybrid arrangements is disclosed that can be implemented using integrated waveguide technology. The apparatus enables sampling of picosecond pulses up to 640 Gb/s with high sensitivity and temporal resolution.